Original article

Neuroanatomical aspects of the body awareness

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Abstract

The cerebral cortex is the most complex part of the human brain and is responsible for thinking, reasoning, cognitive functions, memory and sensory perception processes, among others. The cerebral cortex can be classified into areas, from the specific functions it performs. Particularly noteworthy are the cortical areas, which integrate from multimodal stimuli and enable the individual to perceive his own body and its relationship with the space around it. This capacity is built from the attitudes and values that the individual has in relation to his or her body (body image) and the dimensional perception of its segments (body schema). This process depends on complex neural mechanisms that are related to different cortical areas. The aim of this study was to compare the cortical areas involved in the construction of body perception: body image and schema. As a result, it was observed that the areas with predominance in the perception of body size are more related to the right parietal region and those related to cognitive aspects are located in the prefrontal area and parts of the limbic system.

Keywords: body schema, body image, cortical areas, morphology.

1 Introduction

The capacity of the brain to represent a model of human anatomy occurs quite early. The ability to perceive the body segments (limbs, head, neck and trunk), is a fundamental requirement for daily interaction with the environment, and provide guidance for the preparation of movement and contributes to the formation of body awareness (VIGNEMONT, 2010). The proprioceptive information plays an important role in signaling the posture, in performing movements and the capacity to perceive the shape and location of body parts. However, studies show that in addition to this information, there is also a complex interaction with the visual, tactile and auditory mechanisms (MARAVITA, SPENCE and DRIVER, 2003).

In addition to the dimensional component, one should take into account the attitudinal dimension, which analyzes behaviors, emotions and cognitions of the subject regarding his or her appearance (TAVARES, CAMPANA, TAVARES FILHO et al., 2010). Therefore, the construction of body perception encompasses somatosensory information, concepts, feelings and attitudes toward the body and dynamic organization of the body and its relationship with the environment.

Thus, body perception is based on two distinct and interrelated components: the construction of body perception involves sensory information, concepts and ideas about the dynamic organization of the body itself and its relationship with the environment. Thus, two very distinct and interrelated components can be perceived: the body schema (BS) that consists in sensorimotor representations of the body that guide movements and the body image (BI) that includes all the other representations about the body that are not used for movements, whether they are conceptual or emotional (VIGNEMONT, 2010).

In addition to the conceptual analysis of body perception, it is important to investigate the complex neuronal connections that determine the individual's capacity to associate with him or herself and with the surrounding environment.

The cerebral cortex receives multimodal sensory afferents that interact with the motor system, providing information about body limits, body position and its interaction with objects and the environment (HEAD and HOLMES, 1911). The sensorimotor sequence and the manner the body is perceived in the brain occur in a complex and dynamic way. A recent study shows that the body schema is partitioned into representations that interact with each other (MEDINA and COSLETT, 2010).

Several lesions in the central (stroke) or peripheral nervous system (phantom limb) and various diseases (personal neglect and eating disorders) can cause changes in the BI or BS, and, therefore, to know the cortical organization is an important aspect for the understanding of their mechanisms and disorders.

Although several authors have described and analyzed by neuroimaging techniques, the cortical areas involved in the mechanisms of body perception, to date these findings have not been compiled aiming at mapping the location of these areas (TAVARES, 2003).

Therefore, this review aims to describe the cortical areas related to the BS and BI.

2 Body schema (bs) and body image (bi)

The definition of terms BI and BS has been used in several ways, with different concepts and sometimes interchangeably, leading to methodological and conceptual confusion in several areas of study. In this article, we will

use the differentiation of these terms as recommended by some authors (PAILLARD, 1999; STAMENOV, 2005; MULLIS, 2008; VIGNEMONT, 2010).

The BS is assigned to multimodal somatosensory stimuli (HEAD and HOLMES, 1911), and they provide a constant signaling that work on the immediate recognition of our body due to the interrelationship of its parts, with the space and the objects around it (MARAVITA and IRIKI, 2004). The organization of proprioceptive sensations in relation to the outside world is essential to human movement and thus, the BS acts as a guide for the movements (HOLMES and SPENCE, 2004). The BS has a plastic capacity, that is, any proprioceptive and/or exteroceptive alteration can modify it (MARAVITA and IRIKI, 2004).

The body image, in contrast, can be defined as a complex set of intentions and dispositions about beliefs, attitudes and perceptions in which the main object is one's own body (MULLIS, 2008). The BI is the mental representation of the body, involving all the forms that the individual experiences and conceptualizes. It is a particular phenomenon structured in the existential and individual experience of each human being: with oneself, with others and with the universe; it is a combination of neural processes with its plastic characteristic and the environmental, social and psychological subtleties. The emotions, values, personal history expressed in gestures, looks and body movements are present in the BI (TAVARES, 2003).

Therefore the BI and BS act inseparably and interact with each other all the time.

3 Anatomic representation of body schema

The cortical representation is constructed through the integration of perception of the human body limits and its relationship with the surrounding space. For this body/space interaction to exist, it is necessary to recognize three important dimensional variables: personal space, peripersonal space and extrapersonal space. Personal space is the neural representation of the body surface, responsible for determining its relationship with the spaces around it (peripersonal and extrapersonal space). The peripersonal space concept is that of the space immediately around the body that can be reached by hand and extrapersonal space is one that is beyond the reach of extended limbs (HOLMES and SPENCE, 2004).

The cortical areas related to body schema are located specifically in the supramarginal and angular gyri of the inferior parietal lobe (Figure 1). However there are connections with other cortical areas that receive visual, auditory and vestibular information, such as the superior parietal lobe and temporal lobe, which in turn project on the motor areas of the frontal lobe (premotor area and supplementary motor area) the information that was integrated, thus serving as a guide for movement (MACHADO, 1981; HOLMES and SPENCE, 2004; MOOSHAGIAN, KAPLAN, ZAIDEL et al., 2008; PIETRINI, CASTELLINI, RICCA et al., 2010).

Evidence of the connections between the parietal lobe and body schema were observed when examining subjects with eating disorders. These individuals, who had a distorted perception of body size, showed less activation in this region

Figure 1. Scheme representing the cortical areas (supero-lateral surface) related to body schema (blue) and body image (red).

(EHRSSON, KITO, SADATO et al., 2005; MOHR, ZIMMERMANN, RÖDER et al., 2009).

Studies have shown that there is a specific location of the representation of body segments. Graziano, Cooke and Taylor (2000) observed in both animal models and humans, that the representation of the peri-manual space, both somatosensory and visual, are located in the intraparietal sulcus (Figure 1).

Studies in monkeys and humans have shown that the complexity of sensorimotor integration follows an anterior-posterior hierarchy in the postcentral gyrus and that the most caudal area of this gyrus is the area related to the perception of the peripersonal space and the formation of body schema. This hierarchical scheme suggests that the somatosensory complexity is even higher in the parietal lobe, which is the secondary somatosensory area (IWAMURA, 2003).

Based on the multimodal information and the integration of cortical areas, the body schema is partitioned into three representations: body surface, bordered by the skin; the representation of shape and size and finally the relationship of body segments between them and the space around them (MEDINA and COSLETT, 2010), thus allowing individuals to harmoniously relate with their functional spaces.

4 Anatomic representation of body image

The cortical regions related to body image construction are distinct from the areas related to body schema. However, just as the body schema and body image together constitute body awareness, cortical areas are interconnected so as to integrate the concept of location and size of body segments and the concept of the body itself. One can mention as areas mainly related to body image: the prefrontal area and the limbic system, which are associated with cognitive and emotional components of the body. These inferences were made possible through studies based on diseases of which main symptom is body image distortion (BERLUCCHI and AGLIOTI, 2010).

Among these diseases are the aforementioned eating disorders, in which the subject presents a distorted perception of his/her body size, as well as manifests cognitive alterations related to the appraisal of one's body. These studies used

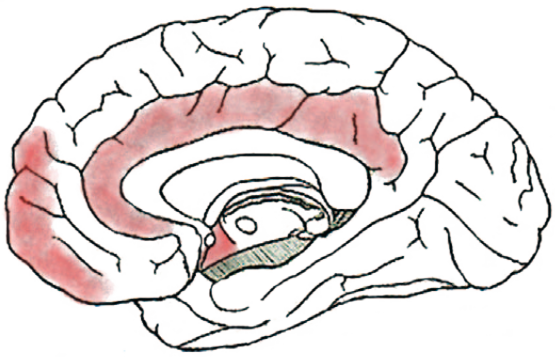

Figure 2. Scheme representing the cortical areas (medial surface) related to body image (red).

neuroimaging evaluation to examine the cortical activation and revealed that the prefrontal area (Figure 2) and the amygdala were more active in patients with these alterations (MIYAKE, OKAMOTO, ONODA et al., 2010). In another study, in addition to the prefrontal area, the authors observed abnormal activation in the cingulate cortex (PIETRINI , CASTELLINI, RICCA et al., 2010) (Figure 2). Uher and Treasure (2005) in their review article also correlated the hypothalamus, the frontotemporal circuitry, the putamen and the pituitary as altered areas in individuals with eating disorders, which can be either a hyper-or hypoactivation, depending on the specific disorder (anorexia nervosa or bulimia).

In addition to the aforementioned areas, the researches by Stamenov (2005) and Downing, Jiang, Shuman et al. (2001) added to the previous set of cortical regions the area of visual perception of oneself, which is located specifically in the right lateral occipital-temporal cortex,. This area works as a specialized neural system for visual perception of the human body in relation to its position and configuration and someone else's body.

5 Final considerations

It has been well established that the cerebral cortex does not work in a segmented manner. Several studies have indicated that motor areas have somesthetic afferences and that somesthetic areas are directly related to motor areas. This concept is also true when it comes to body perception, as the theorists always point out the inseparability between the dimensional and conceptual issues related to the body.

Therefore, we cab observe that the areas with a predominance of body size perception are more related to the right temporo-parietal region, whereas those related to the cognitive aspects are located in the prefrontal area and parts of the limbic system.

Currently the dichotomous conception of the body has been abolished in the conceptual framework, and we observed, based on this study, that within the framework of Cartesian science, it increasingly becomes a concrete truth.

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